SLOW SAND FILTER TEST

Slow Sand Filter Test Units

The purpose of the slow sand filter in the process trains was to act as a final polishing step to remove particulate selenium from the drainage water. Particulate selenium is elemental selenium and selenium that is incorporated into bacterial cells or other particulates. The treatment process(es) upstream of the sand filters reduce the selenate and selenite forms of selenium to the particulate state. Selenium in raw agricultural drainage water is 85 percent to 95 percent in the selenate state, the most soluble form of selenium. The sand filter removes the particulate selenium as the water passes though the filter. Additional biological selenium reduction occurs in the filter as the water passes through the schmutzdecke, the biological mat which forms on the surface of the sand filter.

Both slow sand filters used in testing at the Adams facility were identical to one another. Each consisted of a clear acrylic column with nominal diameter of 14 inches and height of 60 inches. The filter media consisted of 18 inches of coarse sand over 12 inches of a gravel base. The unit was fitted with an influent strainer, influent pump, feed flowmeter, backwash pump, and other appurtenances. A schematic for the slow sand filter is shown in Figure 46.

Sand Filters 1 and 2 Operations - October 14, 1993 through November 2, 1994

Testing with the SSFs began on October 14, 1993 (Day 395) and ended in November 2, 1994 (Day 779). SSF1 treated the effluent of FBR1 and was the third stage of Process Train 1. SSF2 treated the effluent of the UASBR and was the second stage of Process Train 2. Operation of the filters paralleled one another. The feed flow rate into each filter was maintained at 0.5 gpm throughout the testing period. The filter media was changed once, on October 25, 1993 (Day 406), from a #20 sand to a coarser #12 sand to help minimize rate of head loss through the filters to decrease the need to backwash. On July 14, 1994 (Day 638), the source of backwash water was changed to water in tank T3 from the Adams facility's service water system. Tank T3 contained effluent from all the process trains and was of a lower dissolved oxygen concentration than water from the service water system.

Since the filters treated the effluent from either FBR1 or the UASBR, filter operations were coordinated with the operation of those upstream processes. Problems of the upstream processes were, in many instances, carried to the filters. Operations were labor intensive. Backwash was required daily. Gas, which accumulated in the filter media and reduced flow through the filter, would periodically have to be relieved by tapping the side of the column with a rubber mallet. Also, the filters required cleaning to remove growth and precipitant. Due to the amount of work required to keep the filters in operation, testing with the SSFs was discontinued at the beginning of November 1994 to concentrate on the operation and development of the UASBR and FBR processes.

Slow Sand Filter 1 Results

Slow sand filter 1 was the third and final stage of Process Train 1 which treated the effluent of FBR1. Even though some biological reduction of selenium occurred in the filter, the primary

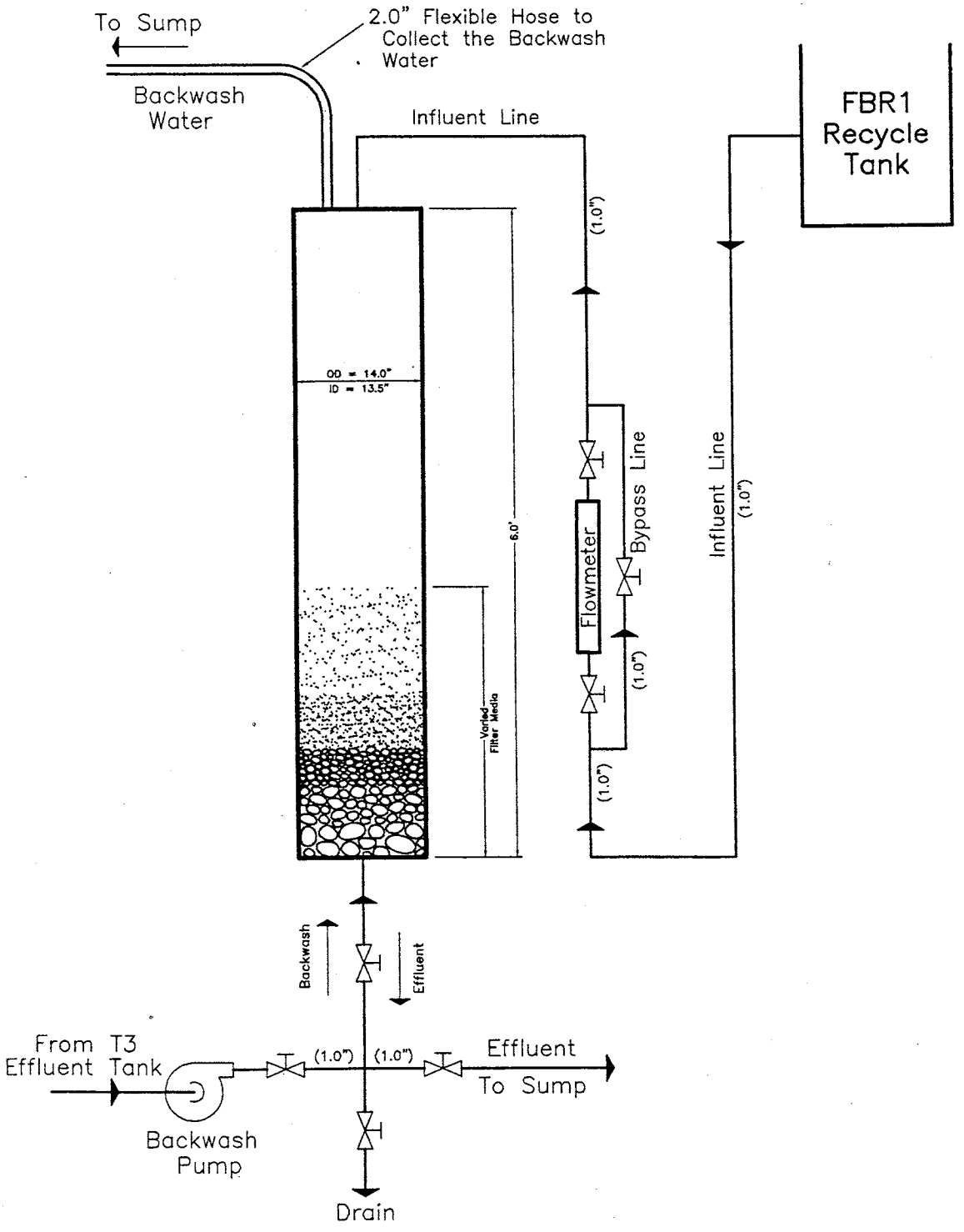


Figure 46. Slow Sand Filter Schematic
(Typical for SSF1 and SSF2)

purpose of the filter was to remove particulate selenium. As described in Table 1, Pse is elemental selenium and selenium incorporated into bacterial cells or other particulates. Pse is equal to total selenium (Tse) minus soluble selenium (Sse). SSF1 was shut down for two prolonged periods from February 27, 1994 (Day 531) through March 15, 1994 (Day 547) for repair and maintenance activities and from April 27, 1994 (Day 590) through May 9, 1994 (Day 602) due to operational problems with the UASBR.

Influent and effluent total and soluble selenium concentrations are shown in Figures 47 and 48. For the 12-month test period, the influent and effluent Tse concentrations averaged 430 ug/L and 236 ug/L, and the influent and effluent Sse concentrations averaged 190 ug/L and 107 ug/L, respectively. The influent and effluent Pse concentration is shown by Figure 49 and averaged 241 ug/L and 102 ug/L for the period. This represents a Pse removal of 57.7% by the filter.

Total treatment by the filter process is determined by the Tse removed. The percentage of Tse removed is shown by Figure 50 and averaged 45.1% for the 12-month period.

Influent and effluent nitrate and total organic carbon concentrations are shown by Figures 51 and 52, respectively. Except for a few instances, the effluent was less than the influent for both constituents. Influent and effluent nitrate concentrations averaged 3.1 mg/L and N and 2.9 mg/L as N, and the influent and effluent TOC concentrations averaged 51 mg/L and 33 mg/L, respectively.

Influent and effluent total and volatile suspended solids are shown in Figures 53 and 54. Influent and effluent TSS concentrations averaged 52 mg/L and 26 mg/L, respectively, while VSS concentrations averaged 31 mg/L and 11 mg/L for the duration of testing.

Slow Sand Filter 2 Results

Slow sand filter 2 was the second and final "polishing" stage of Process Train 2 and treated the effluent of the UASBR. The primary purpose of the filter was to remove particulate selenium even though additional biological reduction of selenium occurred in the filter. SSF2 was shut down for one prolonged period from April 27, 1994 (Day 509) through May 9, 1994 (Day 602) due to operational problems with the UASBR.

Influent and effluent total and soluble selenium concentrations are shown by Figures 55 and 56. For most of the time, the effluent concentration was less than the influent. One major spike occurred on July 13, 1994 (Day 667) where Tse and Sse effluent values reached 1373 ug/L and 720 ug/L, respectively. The operation log noted problems due to green biological growth on top of the filter media and stated that the backwash water was suspect. On July 14, a new backwash technique was instituted using processed water from tank T3 in lieu of the plant's service water. Tank T3 contained the treated effluent (low dissolved oxygen concentration) from the process trains and single stage processes. The influent and effluent Tse concentrations averaged 459 ug/L and 279 ug/L (includes spike value) throughout the entire testing period. The influent and effluent Sse concentrations averaged 268 ug/L and 182 ug/L, respectively.

Figure 47
SSF1 - Influent and Effluent
Total Selenium

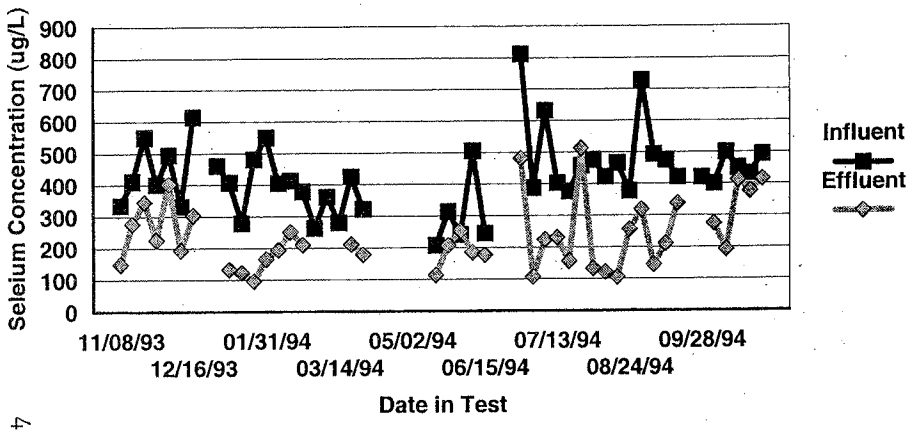


Figure 48
SSF1 - Influent and Effluent
Soluble Selenium

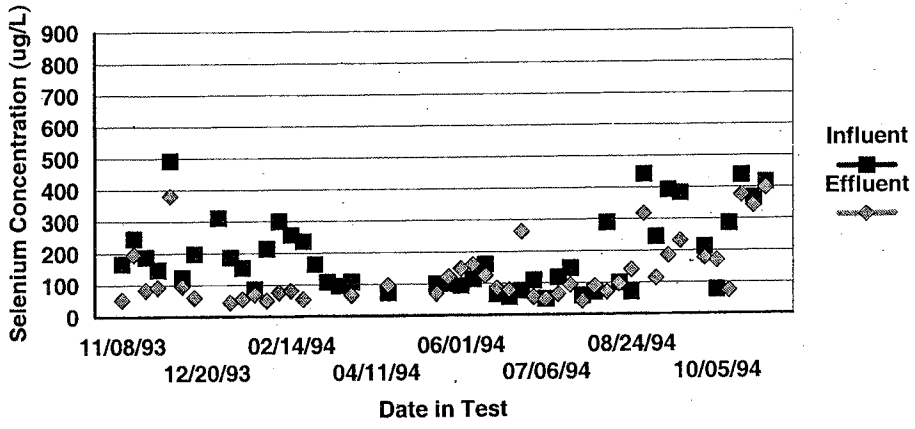


Figure 49
SSF1 - Influent and Effluent
Particulate Selenium

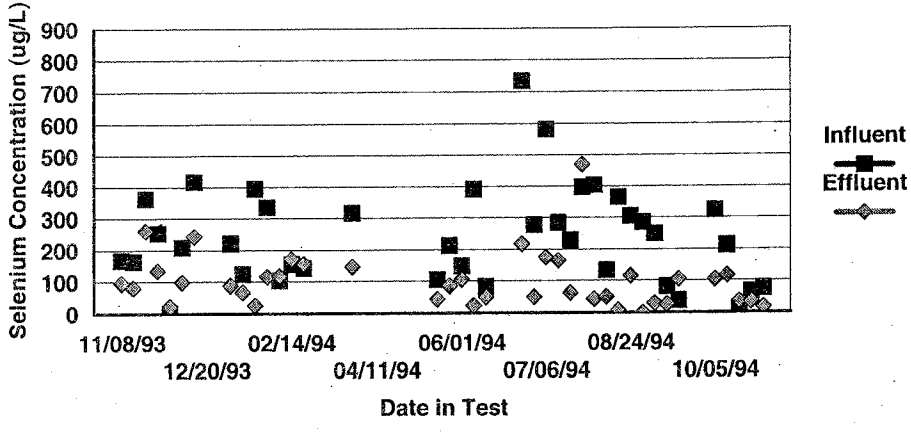


Figure 50
SSF1 - Percentage of
Total Selenium Removed

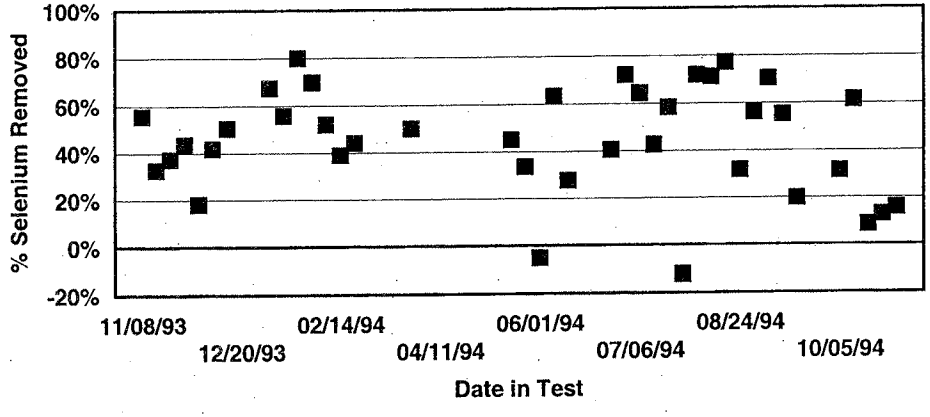


Figure 51
SSF1 - Influent and Effluent
Nitrate

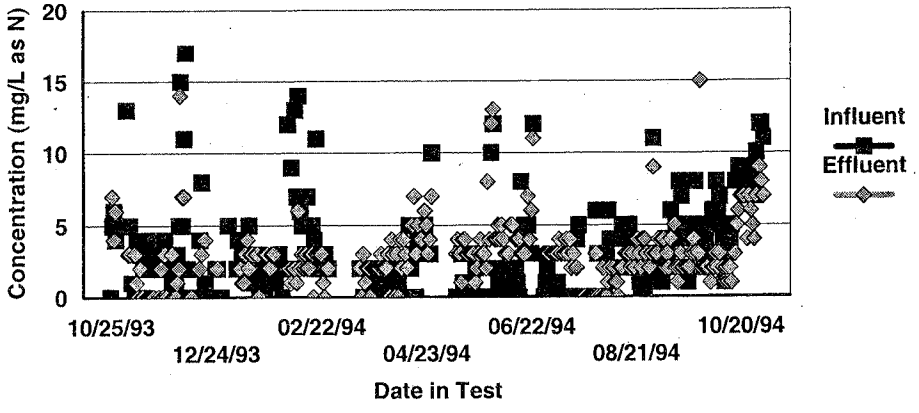


Figure 52
SSF1 - Influent and Effluent
Total Organic Carbon

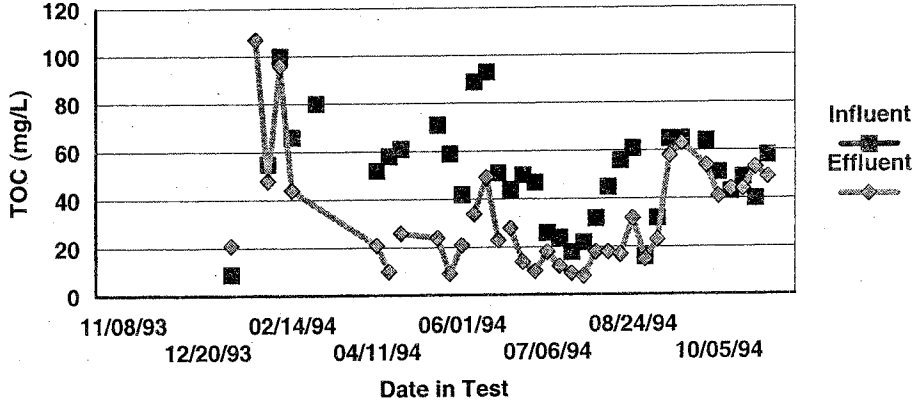


Figure 53
SSF1 - Influent and Effluent
Total Suspended Solids

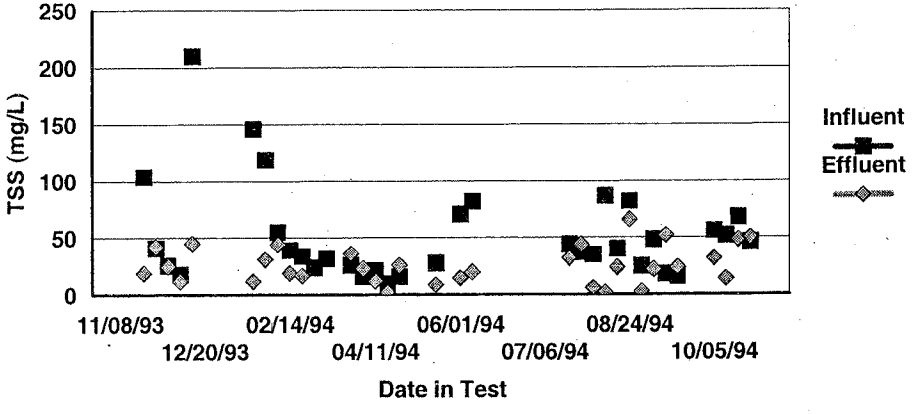
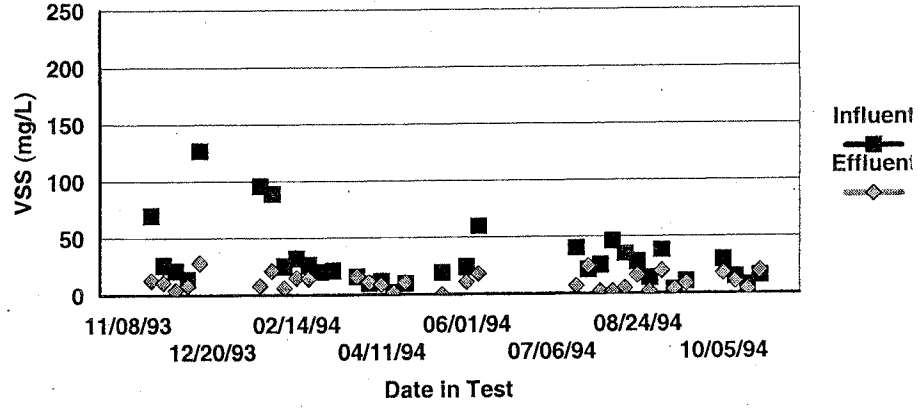


Figure 54
SSF1 - Influent and Effluent
Volatile Suspended Solids



The particulate selenium values are shown by Figure 57, and Figure 58 shows the percentage of Tse removed by the filter. Pse influent and effluent concentrations averaged 184 ug/L and 93 ug/L (79 ug/L excluding spike), respectively. The percentage of Tse removed by the filter averaged 35.5% including the spike value and 41.1% excluding the spike value.

Influent and effluent nitrate and total organic carbon concentrations are shown by Figures 59 and 60, respectively. Generally the effluent values were lower than the influent ones. The influent and effluent nitrate concentrations averaged 7.5 mg/L as N and 3.8 mg/L as N and the influent and effluent TOC values averaged 55 mg/L and 41 mg/L, respectively.

Influent and effluent concentrations for total and volatile suspended solids are shown in Figures 61 and 62. TSS influent and effluent concentrations average 51 mg/L and 26 mg/L, and the VSS concentrations averaged 26 mg/L and 11 mg/L, respectively for the 12-month test period.

Figure 55
SSF2 - Influent and Effluent
Total Selenium

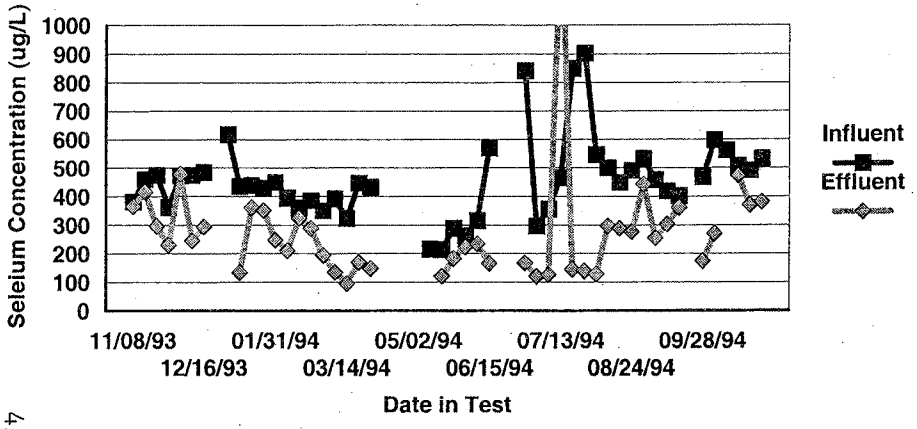


Figure 56
SSF2 - Influent and Effluent
Soluble Selenium

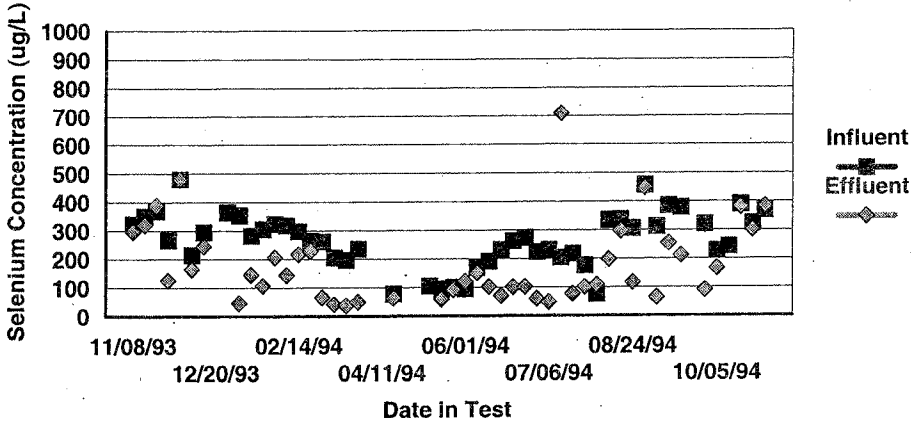


Figure 57
SSF2 - Influent and Effluent
Particulate Selenium

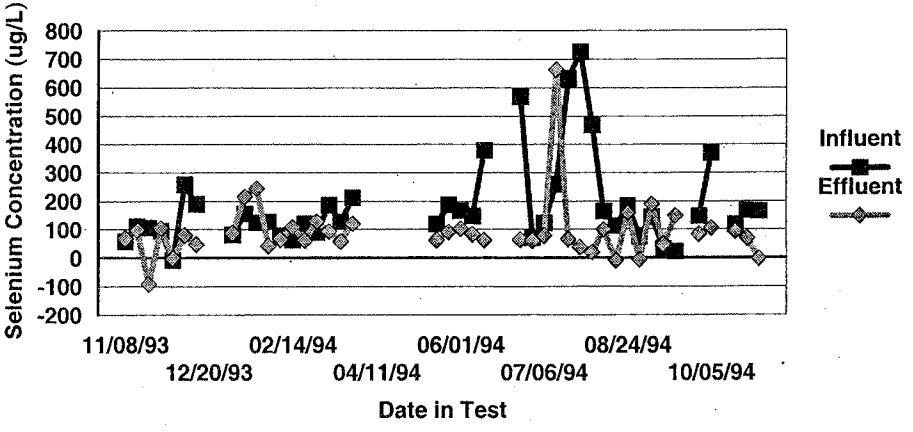


Figure 58
SSF2 - Percentage of
Total Selenium Removed

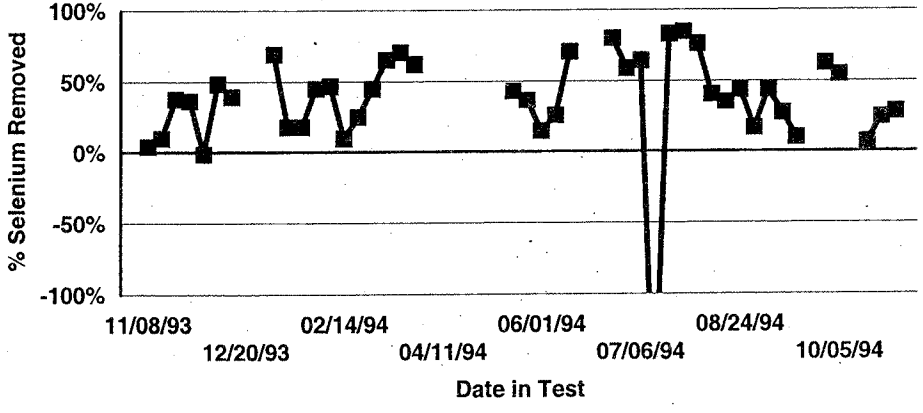


Figure 59
SSF2 - Influent and Effluent
Nitrate

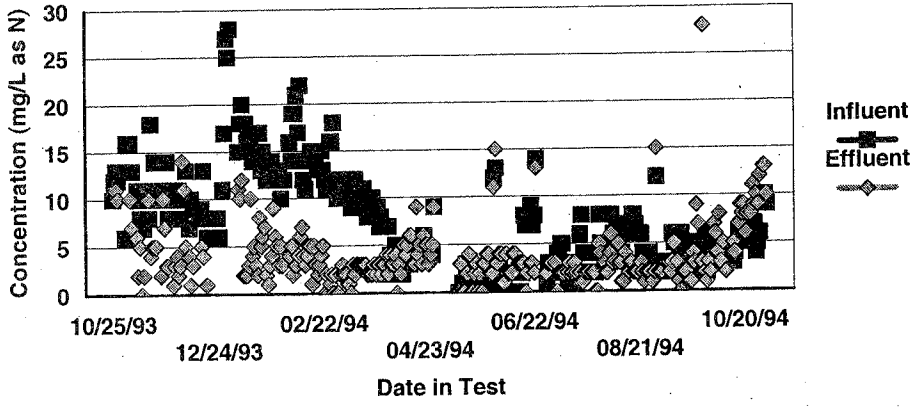


Figure 60
SSF2 - Influent and Effluent
Total Organic Carbon

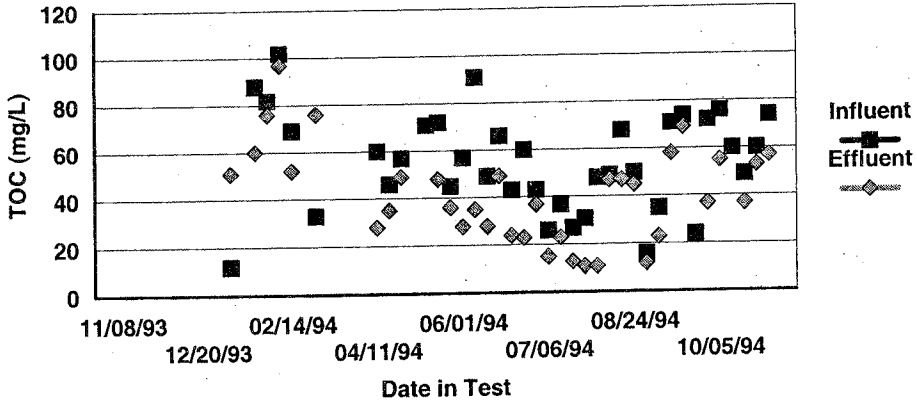


Figure 61
SSF2 - Influent and Effluent
Total Suspended Solids

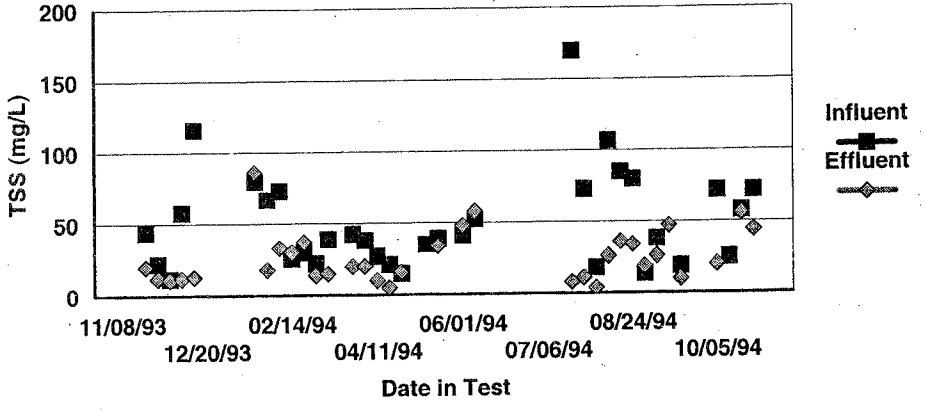


Figure 62
SSF2 - Influent and Effluent
Volatlile Suspended Solids